Symptomatic Os Acromiale

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Abstract

Os acromiale, the joining of the acromion to the scapular spine by fibrocartilaginous tissue rather than bone, is an anatomic variant that has been reported in approximately 8% of the population worldwide. It is more common in blacks and males than in whites and females. Although it is often an incidental finding, os acromiale has been identified as a contributor to shoulder impingement symptoms and rotator cuff tears. When nonsurgical management of a symptomatic os acromiale fails to relieve symptoms, surgical intervention is considered. Options include os acromiale excision, open reduction and internal fixation, and arthroscopic decompression. Excision usually is reserved for small to midsized fragments (preacromion) or after failed open reduction and internal fixation. Persistent deltoid dysfunction may result from excision of a large os acromiale. Open reduction and internal fixation preserves large fragments while maintaining deltoid function. Cannulated screw fixation has been shown to result in good union rates. Arthroscopic techniques have shown mixed results when used for treating impingement secondary to an unstable os acromiale. Associated rotator cuff tears may be addressed arthroscopically or through an open transacromial approach, followed by open reduction and internal fixation of the os acromiale.

Gruber,[1] in 1863, first reported on separation of the acromion in a study of 100 cadavers; 3 of the 100 specimens exhibited a fibrocartilaginous union of the acromial ossification centers. Numerous other anatomists have produced descriptive studies of os acromiale.[2-4] The reported incidence ranges from 1.3% to 30%.[5-10] The relatively high 30% rate was reported in an archeological study of remains from an excavated cemetery.[7] The rate is attributed to familial ties of the persons buried in that cemetery. Two separate studies of the Hamann-Todd Osteological Collection discovered an 8% incidence of os acromiale (17 of 210 specimens), with roughly one third having bilateral involvement.[9,10] In addition, these studies revealed that blacks and males were twice as likely to have an os acromiale as whites and females, respectively. Other reports indicate bilateral involvement in as many as 62% of patients.[6]

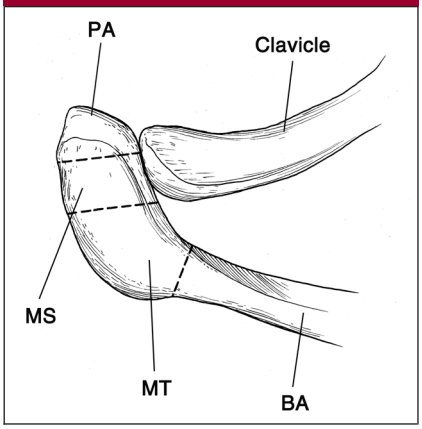
Anatomy

An os acromiale represents a failure of fusion of the anterior acromial apophysis. The acromial apophysis develops from four separate centers of ossification: the basiacromion,

meta-acromion, mesoacromion, and preacromion (Figure 1). The basiacromion fuses to the scapular spine at approximately age 12 years. The meta-acromion serves as the origin of the posterior deltoid muscle, and the mesoacromion anchors the middle tendinous portion of the deltoid. The preacromion is the attachment site for both the anterior deltoid fibers and the coracoacromial ligament. The three anterior acromial ossification centers develop from several ossification nuclei, but by between ages 15 and 18 years, they coalesce into the meta-acromion, mesoacromion, and preacromion. Complete union of all centers may occur as late as age 25 years;[11] therefore, caution is warranted when diagnosing an unfused os acromiale before that age. Some authors dispute the concept of four discrete ossification centers and contend that the acromion ossifies from one continuous cartilaginous anlage.[8]

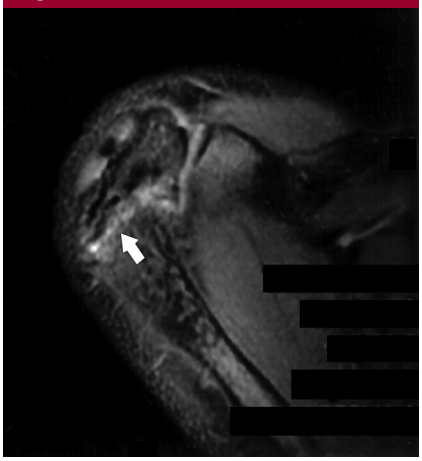
The types of os acromiale are defined by the unfused segment immediately anterior to the site of nonunion. For example, failed fusion between the meta-acromial and mesoacromial ossification centers is called a mesoacromiale. The great majority of ossa acromiale are mesoacromial.[8-11] Preacromial fragments occur much less frequently, and a meta-acromiale is rare (Figure 2). Mudge et al[12] reported on the extremely rare variant of a preacromial and mesoacromial double fragment.

Figure 1



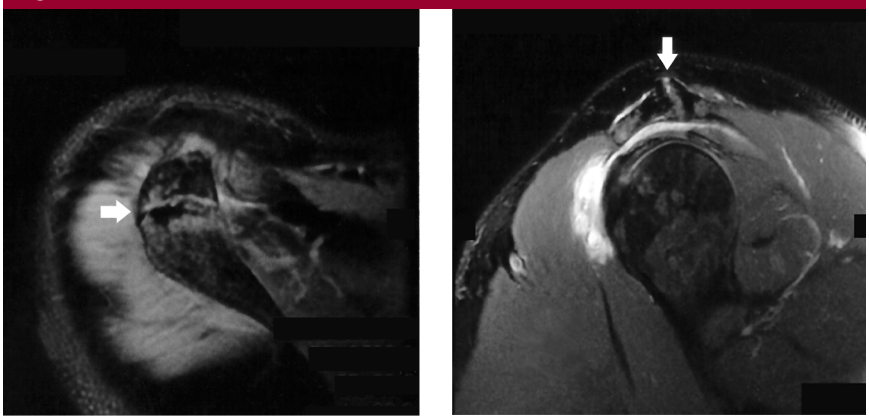
The acromial ossification centers comprising the acromial apophysis. BA = basiacromion, MS = mesoacromion, MT = meta-acromion, PA = preacromion

Figure 2



Axial T2-weighted MRI scan demonstrating a meta-acromiale of the right shoulder. The site of nonunion is indicated by the arrow.

Figure 3



A **B**

A, T2-weighted axial MRI scan of the right shoulder demonstrating reactive edema at the nonunion site (arrow). **B,** T2-weighted coronal oblique image of the same patient demonstrating superior osteophyte formation (arrow).

Pathophysiology

Os acromiale is often an incidental radiographic finding discovered while examining a patient with shoulder pain. The os acromiale may be completely unrelated to the true source of the patient's discomfort.[13] A complete evaluation for all sources of potential pain must be undertaken before attributing symptomatology to the os acromiale.

In patients in whom the os acromiale is believed to be pathologic, the pain-generating potential from an unstable os likely stems from two main sources. First, the nonunion site may be inherently painful, with pain directly at the nonunion site. Physical findings include tenderness at the nonunion site or localized pain with manipulation of the unstable fragment. Furthermore, magnetic resonance imaging (MRI)[14] (Figure 3) and bone scan[15,16] may demonstrate evidence of inflammatory reaction at the site of nonunion. Second, an unstable os acromiale may produce a dynamic type of outlet-based impingement syndrome.[15,17,18] Both flexion of the anterior fragment with deltoid contraction and elevation of the arm can decrease the size of the supraspinatus outlet, thereby producing the symptoms of classic external impingement.[15,18]

Figure 4

A B C

Anteroposterior **(A)**, outlet **(B)**, and axillary lateral **(C)** radiographic views of the right shoulder in the same patient. The os acromiale is most readily apparent on the axillary lateral projection (black arrow in panel C).

Patient Assessment

In patients with symptomatic os acromiale, complaints are frequently those of classic outlet impingement syndrome.[16-22] Patients relate difficulty with overhead activities and with sleeping. They may report limited range of motion or clicking in the shoulder.[12,17] Patients also describe pain located directly over the superior acromion, especially when the fragment becomes more unstable.[15,22,23] Finally, patients may notice weakness caused by associated rotator cuff dysfunction.[12,24] A history of trauma is less common; if present, its role in the development of os acromiale is usually minor.

A standard physical examination reveals many findings of classic impingement, including pain with impingement signs, painful arc of motion, and difficulty with forward elevation, even in the presence of an intact cuff.[15] Rotator cuff weakness is often present.

In addition to the typical impingement findings, the physical examination may reveal abnormalities unique to an unstable os acromiale. The patient may experience tenderness directly at the nonunion site; further, gross motion of the anterior acromion may be present. A diagnostic subacromial injection (impingement test) may give a mixed response, with alleviation of impingement signs but with variable relief of the localized tenderness. In the presence of uncertainty regarding the source of localized tenderness, a diagnostic injection into the nonunion site itself may be beneficial.

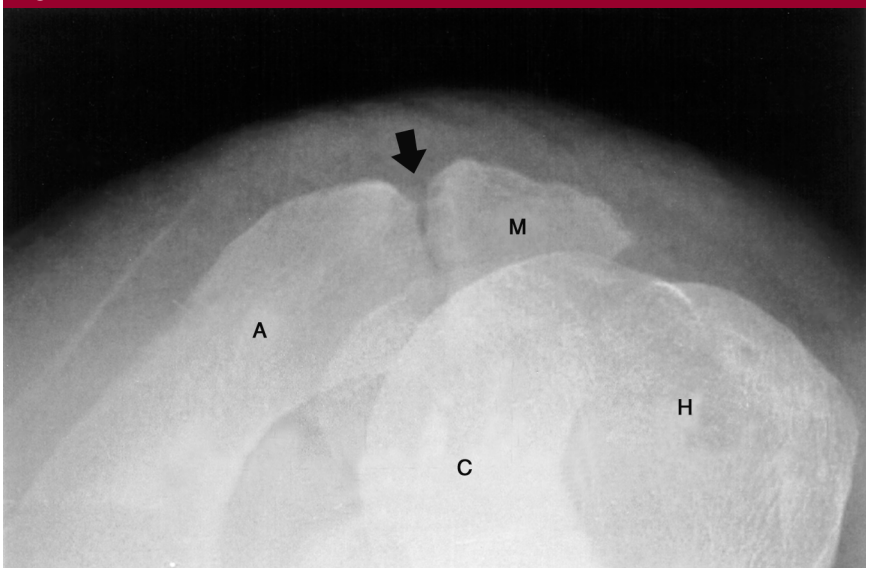
Radiographic Assessment

Three-view tangential radiographs are essential for assessing any patient with shoulder problems. With os acromiale, the axillary lateral view is essential. An os acromiale is easily missed with anteroposterior or y-view scapular radiographs. Most authors stress that the axillary lateral view is critical[8,12,15-17,19-21,23,25] (Figure 4). The axillary lateral view reveals the size and shape of the acromial fragment as well as any degenerative change at the site.

In addition to the standard axillary lateral view, the acromial profile view described by Andrews et al[26] (Figure 5) provides another means of detecting an os acromiale that is not readily apparent on more conventional views. Plain radiographs of the contralateral shoulder may be helpful, especially when evaluating a patient who is not skeletally mature. With contralateral views, however, the incidence of bilateral involvement may be as high as 62%.[6]

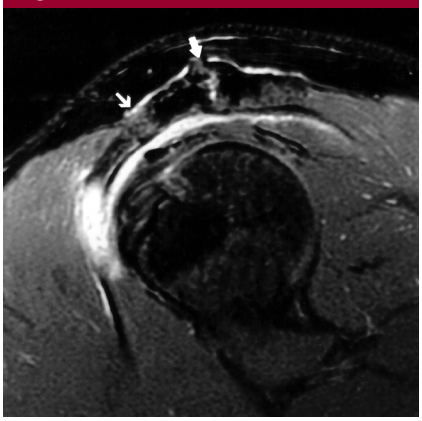
MRI is a helpful and frequently

Figure 5



Acromial radiographic profile view of the right shoulder in a patient with a mesoacromiale. The arrow indicates the site of nonunion. A = acromion, C = clavicle, H = humeral head, M = mesoacromiale

Figure 6



T2-weighted coronal oblique MRI scan of the left shoulder. The acromioclavicular joint is anterior (narrow arrow), and the acromial defect is posterior (wide arrow).

used adjunct in radiographic evaluation of the shoulder. Axial cuts through the acromion reliably detect an os acromiale. When the axial projection is either incomplete (ie, not taken superior enough to include the acromion) or absent, other orientations may offer more subtle clues. The sagittal and oblique cuts are easily misinterpreted. For instance, the os acromiale may be mistaken for the acromioclavicular joint. The presence of a double acromioclavicular joint on a single image (Figure 6) should raise the suspicion of an os acromiale; however, this finding is often not present.[14] In most patients, the os acromiale defect appears as a vertical band of low signal intensity in a position posterior to a line bisecting the humeral head on oblique sagittal images.[14,27] This is in contrast with the acromioclavicular joint, which lies anterior. MRI also may detect hypertrophic osteophyte formation, edema, or widening at the site of nonunion, indicating instability of the os acromiale.[27] Finally, MRI is useful for confirming the presence of other associated pathology, such as rotator cuff tears.

Other imaging modalities also may be helpful in evaluating an os acromiale. Computed tomography (CT) readily delineates an unfused acromion on the axillary projection.[20,22] Three-dimensional CT reconstructions clearly show the os acromiale.[20] Bone scanning, when positive, is useful in confirming the os acromiale as a contributing factor in a painful shoulder,[15,16] especially when evaluating a patient on the cusp of skeletal maturity.

Nonsurgical Management

Initial management of the symptomatic os acromiale should be nonsurgical. Nonsteroidal anti-inflammatory drugs should be prescribed, as well as physical therapy with an impingement protocol. Subacromial corticosteroid injection also may be used. Local corticosteroid injection at the nonunion site may provide sufficient relief of symptoms to avoid surgery.[16] Generally, nonsurgical management should be tried for at least 6 months. However, the incidence of a full-thickness rotator cuff tear may be as high as 50%;[15,18] such a tear may be grounds for early surgical management.[28]

Surgical Management

Surgical management is warranted when nonsurgical treatment fails. A number of surgical approaches have been advocated, including fragment excision, open reduction and internal fixation (ORIF), and arthroscopic subacromial decompression. Various techniques are reported for each approach, and each procedure has benefits and drawbacks.

Open Fragment Excision

Open fragment excision has had mixed results. Mudge et al[12] treated six patients with excision in conjunction with rotator cuff repair. Four patients had excellent results; the remaining two were poor. Despite their results, Mudge et al[12] advocated ORIF and bone grafting for larger fragments. Edelson et al[8] reported an anatomically based technique of excision and deltoid advancement in five patients; four of

five patients were satisfied. The authors attributed the one failure to an irreparable rotator cuff tear and concomitant distal clavicle resection resulting in superior humeral head migration and loss of forward flexion. As a result, they recommended ORIF in the presence of an irreparable rotator cuff tear.

Warner et al[15] performed fragment excision on three patients; two had poor results. Both poor results involved mesoacromial fragment excision with resultant pain and weakness. The one satisfactory result involved resection of a preacromiale. In general, patients who undergo open resection of the anterior acromion are at high risk for deltoid dysfunction;[29] thus, open fragment excision should be reserved for very small fragments or as a salvage procedure for patients with failed attempted ORIF.[15,17]

Open Reduction and Internal Fixation

Numerous case reports[19,22,24] and case series[8,15,18,25,30] have been published regarding ORIF of an unstable os acromiale. Nearly all techniques involve some sort of internal fixation with bone grafting. Edelson et al[8] treated two patients with ORIF consisting of malleolar screw fixation and local bone grafting. Both achieved union, and both required hardware removal. The indication for fusion rather than excision was primary pain at the nonunion site with absence of impingement symptoms. Warner et al[15] performed ORIF on 11 patients (12 shoulders) with two techniques, both of which involved débridement of the nonunion site and bone grafting perpendicular to the nonunion via a bone trough. Five of 12 shoulders were fixed with pins and tension band wiring; 4 of 5 failed to unite. In contrast, only one failed fusion was reported in seven shoulders fixed with cannulated screws and a tension band construct. Average time to union was 9 weeks. Nine of 12 patients required subsequent hardware removal, including five of seven with successful fusions.

Hertel et al[30] performed ORIF for 15 unstable acromial fragments with takedown of the nonunion and tension band wiring without bone grafting. Two distinct surgical approaches were employed. Seven patients were operated on with an anterior deltoid-off approach, and eight patients with a transacromial approach with preservation of the deltoid origin. Union was achieved in three of the seven deltoid-off patients and in seven of the eight transacromial deltoid-preserving patients. The authors attributed the increased union rate with deltoid preservation to maintenance of the acromial blood supply via the acromial branch of the thoracoacromial artery.

Satterlee[18] reported successful fusion in six of six patients with an unstable os acromiale. The procedure involved dorsal wedge osteotomy and nonunion takedown, elevation of the anterior fragment, fixation with two 4.5-mm Herbert screws, and local bone graft held in place with a figure-of-8 suture passed through the cannulated screws. One patient underwent hardware removal but was asymptomatic. Ryu et al[25] used two parallel 3.5-mm cannulated screws and greater tuberosity bone grafting in four patients. Fusion was achieved in all four, with a time to union of 10 to 16 weeks.

ORIF of an unstable os acromiale is indicated for larger fragments. Success is predictable with any of a variety of techniques. Factors associated with successful union include use of a rigid construct[15,18,25] and preservation of the acromial vascularity.[30] Even with successful union, hardware removal is not uncommon. Pain is the most common reason for hardware removal.

Arthroscopic Subacromial Decompression

Arthroscopic subacromial decompression has been advocated as a means to avoid the complications associated with ORIF (eg, risk of nonunion, revision for hardware removal). Early experience with arthroscopic treatment was not very successful because many patients were treated with simple decompression. Although the deltoid insertion was preserved, standard arthroscopic decompression failed to eliminate the painful nonunion.

Hutchinson and Veenstra[23] reported on three patients who underwent arthroscopic subacromial decompression for impingement syndrome associated with an unstable os acromiale. The authors performed decompression of the entire acromial fragment back to the junction with the intact acromion. Two patients had recurrence of symptoms after a 6- to 8-month period of relief. The third patient was improved but not pain free and required a change in employment to avoid overhead activities. In all patients, the presence of the os acromiale was not discovered until the time of surgery, despite preoperative radiographs revealing its presence. Based on this small series, the authors concluded that standard techniques for arthroscopic subacromial decompression cannot be recommended for impingement secondary to an unstable os acromiale.

Jerosch et al[31] performed 122 arthroscopic subacromial decompressions for impingement syndrome, of which 12 had os acromiale. No patient had a rotator cuff tear. Patients with an os acromiale had a trend toward less favorable results, but the difference did not reach statistical significance. Even with the slightly worse outcomes, the authors recommended arthroscopic subacromial decompression as a reasonable option for managing impingement syndrome with an os acromiale.

In an effort to improve results with standard arthroscopic techniques, Wright et al[21] employed a more aggressive arthroscopic approach for treating os acromiale–associated impingement. They treated

13 shoulders in 12 patients who had failed nonsurgical management; all patients had complete pain relief with preoperative subacromial injections. None of the patients was directly tender at the nonunion site. The authors used a more aggressive bone resection, especially of almost the entire mobile anterior tip, leaving only a thin superior cortical shell. Ten of 12 patients achieved satisfactory postoperative University of California, Los Angeles (UCLA) scores, and 11 of the 12 patients themselves rated the outcome as satisfactory. No complications were reported. The authors concluded that arthroscopic subacromial decompression with resection is a reasonable alternative and can achieve good results, provided that bone resection is adequate.

In addition to addressing the os acromiale and associated impingement syndrome, many patients require concurrent treatment of a rotator cuff tear. A complete tear or significant partial tear should be addressed at the same time as the os acromiale, regardless of the surgical approach selected. With excision, the cuff repair can be achieved through standard open, mini-open, or arthroscopic means, depending on the technique. With ORIF, an acromion-splitting approach is a good option;[24] open repair of the cuff is done through the acromial defect before bone fixation. With arthroscopic decompression, the cuff may be addressed by arthroscopic repair, débridement, or a mini-open approach.

Each surgical technique has advantages and disadvantages. Although open fragment excision may be warranted for the preacromial os, it can result in significant deltoid dysfunction for larger segments. ORIF preserves deltoid function and addresses the os acromiale as a primary pain generator; however, risk of nonunion is a concern, and revision for hardware removal is common. Arthroscopic decompression has minimal risk, but results may be mixed, and pain at the nonunion site may persist. The clinical scenario and surgeon experience are evaluated to determine the technique that will most benefit the patient.

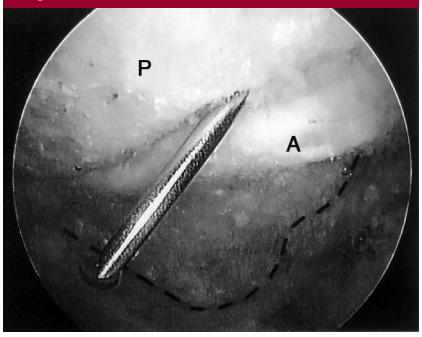
Management Techniques

The initial step in management is determining whether the os acromiale is incidental or symptomatic. Tenderness at the nonunion site, pain with motion of the mobile segment, and imaging studies showing reactive changes are all indications that the os acromiale is not an incidental finding. For patients in whom the os acromiale is determined to be coincidental, management of the other shoulder pathology is indicated. In some instances, impingement may exist in the presence of an os acromiale with a stable fibrous union. A standard arthroscopic subacromial decompression without resection of the os may be indicated in patients who fail nonsurgical treatment.

For the symptomatic os acromiale, a nonsurgical approach is followed, consisting of nonsteroidal anti-inflammatory drugs, physical therapy, and judicious use of subacromial corticosteroid injections. As mentioned, this nonsurgical approach generally is given a 6-month trial unless some other consideration (eg, full-thickness rotator cuff tear) warrants abandonment. For patients who require surgery, the approach is tailored to the individual clinical situation.

A symptomatic preacromial fragment or a small mesoacromial fragment anterior to the posterior aspect of the acromioclavicular joint can be treated with excision using an arthroscopic technique of fragment excision with decompression of the remaining mesoacromion. The fragment is excised to the superior cortical plate, leaving the deltoid intact. The anterior edge of the remaining acromion is smoothed over to the deltoid attachment. An arthroscopic approach preserves the deltoid fascia and allows for treatment of all associated pathology.

Figure 7

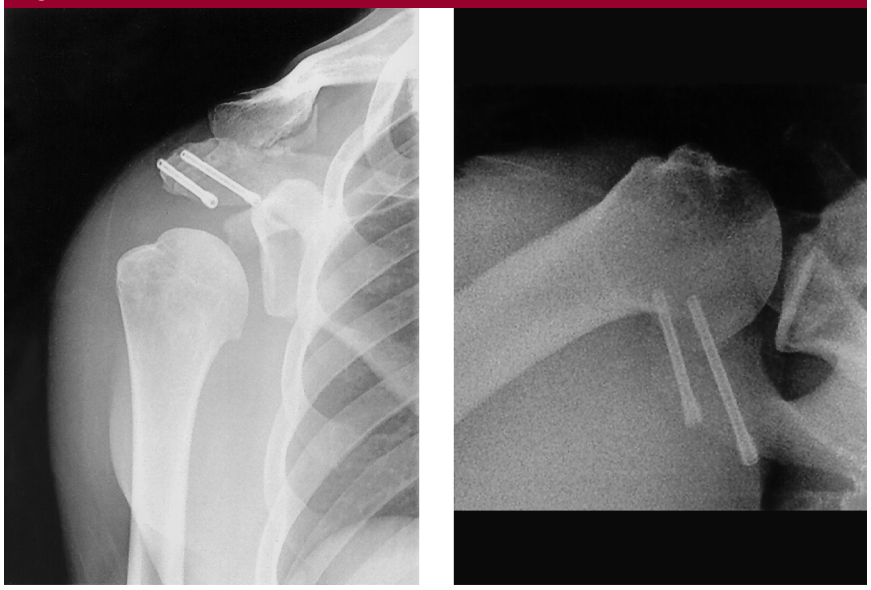


Arthroscopic view of the subacromial space from the posterior viewing portal. A spinal needle was inserted through the acromial defect. Note the downgoing hook on the anterior fragment (dashed line). A = anterior, P = posterior

A symptomatic large mesoacromial fragment is by far the most common presentation. The nonunion is located at or behind the level of the posterior acromioclavicular joint. Arthroscopic examination of the glenohumeral joint always should be performed. Rotator cuff integrity is assessed, and any other associated pathology (eg, superior labral injury) is addressed. Subacromial arthroscopy (Figure 7) should determine both segment motion and rotator cuff disease. Rotator cuff repair may be done arthroscopically if the tear is amenable. When the os is stable, a standard arthroscopic subacromial decompression is performed. In the presence of an unstable os in a patient with low-demand shoulder function, the os is arthroscopically resected to a cortical plate. When it is unstable and the patient requires higher-demand upper extremity function, ORIF should be performed.

ORIF is undertaken via a transacromial approach, as described by Hertel et al.[30] Superior osteophytes

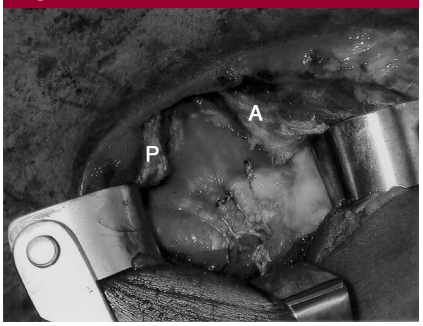
Figure 8



A **B**

Immediate postoperative anteroposterior **(A)** and axillary **(B)** radiographs of the right shoulder following ORIF with 4.5-mm Herbert screws.

Figure 9



Acromion-splitting approach for rotator cuff repair of the right shoulder. The deltoid attachment is preserved for each fragment. A = anterior fragment, P = posterior fragment

are removed, and the nonunion is taken down until bleeding bone is seen on each opposing fragment face. The débridement creates a dorsally based open wedge that allows for elevation of the anterior fragment before fixation. The fragment is elevated and temporarily fixed with Kirschner wires. The wires can be drilled posterior-to-anterior in the anterior fragment, then advanced retrograde after the fragment is reduced. A large tenaculum is used to provide compression of the reduced fragments. Screws may be placed either anterior-to-posterior or posterior-to-anterior. Placing screws posterior-to-anterior avoids compromising the more important anterior deltoid (Figure 8). Compression techniques are used. Standard-head screws may be used, but intramedullary screws will reduce the need for further surgery. Demineralized bone matrix may be added to increase union rates. Substantial bone defects may be grafted with autogenous bone obtained from either the iliac crest or anterior tibia (Gerdy's tubercle). Gerdy's tubercle bone graft is generally less painful than iliac crest graft, and surgical access is easier when the patient is in the beach-chair position. A nonabsorbable suture placed through the screws and looped superiorly in a figure-of-8 configuration will aid not only in securing any bone graft but also in localizing the screws in the event hardware removal is required. An acromion-splitting approach (Figure 9) followed by ORIF is used when an open rotator cuff repair is needed. Subacromial arthroscopy can be performed after ORIF to evaluate for unwanted prominence or a residual acromial hook requiring decompression. The deltoid fascia is closed, and the patient is placed in a shoulder immobilizer.

The patient is kept in an immobilizer for a minimum of 6 weeks postoperatively. Passive motion only is allowed for the initial 6 weeks. Gentle active-assisted and active motion are begun at 6 weeks. Radiographs are obtained at 6 weeks and periodically thereafter until union. Time to union is variable, with an average of 8 to 12 weeks;[15,18,25] however, it may take 16 to 20 weeks to achieve union.[15,25] Strengthening and activity progression are withheld until union is achieved.

Summary

Os acromiale is not an uncommon finding during the workup of a patient with a painful shoulder. An axillary lateral radiograph is critical in identifying an os acromiale. The finding may be incidental or symptomatic. Unstable os fragments generally exhibit high signal or widening on MRI. For the symptomatic os acromiale, management is initially nonsurgical. Surgery is indicated only for patients who fail nonsurgical treatment. Surgical options include arthroscopic sub–total excision, arthroscopic subacromial decompression of stable fragments, and ORIF of unstable fragments. Results are variable, and the surgical approach should be tailored to fit the patient's specific clinical scenario.

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